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APPLICATION NUMBER: ***60/503,009***
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
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☐ *Additional inventors are being named on the ____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 7 ☐ CD(s), Number

☒ Drawing(s) *Number of Sheets* 9 ☐ Other (specify)

☐ Application Data Sheet. See 37 CFR 1.76

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

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Respectfully submitted,

SIGNATURE

Date 09/15/03

TYPED or PRINTED NAME Robin W. Asher

REGISTRATION NO. 41,590 *(if appropriate)*

Docket Number: 19345-095181

TELEPHONE 313-965-8300

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By: _____
Janet H. Fournier

Attorney Docket No : 19345-095181

UNITED STATES

UNITED STATES PROVISIONAL PATENT APPLICATION

FINAL VERSION

For: Differential With Die Formed Housing

Inventors
/Applicants: David Dorigo
Jianwen Li
Cheng Mu
David Mark Pascoe

Assignee: Tesma International Inc.

Date: September 10, 2003

Tesma Ref: ?

Differential With Die Formed Housing

FIELD OF THE INVENTION

[0001] The present invention relates to differentials for vehicles. More specifically, the present invention relates to a differential with at least part of its housing being die formed.

BACKGROUND OF THE INVENTION

[0002] Differentials are employed in vehicles to permit the two wheels on an axle to rotate at different velocities when rounding the slightest corner. In rear wheel drive vehicles, the differential is employed at the rear axle and the converse is true in front wheel drive vehicles. Four wheel drive vehicles employ a differential at each axle.

[0003] Differentials are robustly manufactured as their housings must accommodate high torques and loadings without breaking and without distorting, as the alignment of various components within the differential are critical and require the housing to resist deformations to maintain their alignment.

[0004] Conventionally, differentials have been made with one piece cast iron housings and, due to the relative low strength of cast iron, these housings have required relatively thick walls to carry the expected loads. Further exacerbating this problem is the fact that conventional differential housings typically include a pair of large openings on opposed sides of the housing to permit assembly of the differential. These large openings represent a significant potential weakness in the housing which must be countered by further strengthening the housing by increasing the wall thickness.

[0005] As will be apparent, increasing the amount of cast iron employed in the housing also undesirably increases its weight and volume.

[0006] Previous attempts have been made to provide an improved differential. U.S. Patents 6,061,907 and 6,176,152 to Victoria teach the manufacture of a differential housing from steel using a cold flow-forming and/or cold spin-forming process. By employing steel for the housing, rather than cast iron, the required strength of the housing can be obtained with a thinner gage, lower weight housing.

[0007] While the differential housing taught by Victoria is an improvement over conventional differential housings, it still suffers from disadvantages in that cold flow-forming and/or cold spin-forming are expensive and time consuming manufacturing processes.

[0008] It is desired to have a differential housing of steel or the like and a method of manufacturing the housing which avoids the problems and/or disadvantages of the prior art.

SUMMARY OF THE INVENTION

[0009] It is an object of the present invention to provide a novel differential housing and method of manufacturing the differential housing which obviates or mitigates at least one disadvantage of the prior art.

[0010] According to a first aspect of the present invention, there is provided a differential comprising: a differential housing die-formed from a steel blank including a generally spherical volume within the housing; a subassembly installed in the generally spherical volume of the differential housing and comprising a pinion shaft, a pair of bevel pinions on the pinion shaft and a complementary pair of bevel gears; a housing closure die-formed from steel blank and mounted to the differential enclosure to enclose said subassembly; and a ring gear mounted to said differential housing to receive transmitted torque from a prime mover, the differential housing including a hub portion to accept an axle to engage one of the bevel gears and the housing closure also having a hub portion to accept a second axle to engage the other of the bevel gears.

[0011] According to a second aspect of the present invention, there is provided a method of manufacturing a differential comprising the steps of: (i) forming a differential housing from a steel blank through a series of forming operations with die and punch pairs, the differential housing including a generally spherical volume and a hub portion with a through aperture; (ii) forming a housing closure from a steel blank through a series of forming operations with die and punch pairs, the housing closure including a hub portion with a through aperture; (iii) assembling a sub-assembly of a pinion shaft, at least two bevel pinions and at least two complementary bevel gears; (iv) inserting the sub-assembly into the generally spherical volume in the differential housing such that the through aperture aligns with an inner splined aperture on one bevel gear to receive a splined portion of an axle; (v) mounting the housing closure to the differential housing to enclose the sub-assembly such that the through aperture aligns with an inner splined aperture on the other bevel gear to receive a splined portion of an axle; and (vi) mounting a ring gear to the differential housing.

[0012] The present invention provides a novel differential and method of a making the differential wherein the differential housing and housing closure are manufactured by die-forming to obtain a differential which is both light and strong and reasonably inexpensive to manufacture.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Preferred embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

Figure 1 shows a section through a differential in accordance with an embodiment of the present invention;

Figure 2 shows a partially cut-away perspective view of the differential of Figure 1;

Figures 3a, 3b, 3c and 3d shows the stages of a method of die-forming a differential housing in accordance with an embodiment of the present invention;

Figure 4 shows an isometric view of the differential housing of Figure 3d;

Figures 5a and 5b show the stages of a method of die-forming a differential housing cover in accordance with an embodiment of the present invention;

Figure 6 shows an isometric view of the differential housing of Figure 5b;

Figures 7a, 7b, 7c, 7d and 7e show steps to assemble the die-formed differential of Figure 1;

Figure 8 shows the differential of Figure 1 with different bearings; and

Figure 9 shows the differential of Figure 1 with a welded ring gear.

DETAILED DESCRIPTION OF THE INVENTION

[0014] A differential in accordance with an embodiment of the present invention is indicated generally at 40 in Figures 1 and 2. In these Figures, and the others of this description, like elements are indicated with like reference numerals.

[0015] Differential 40 includes a die formed housing 44, further discussed below, with a flange 46 to which a differential ring gear 48 is attached, in the illustrated embodiment, by rivets 52 although, as will be apparent to those of skill in the art any suitable method of attachment, including bolts, welding, etc. can be employed.

[0016] Torque from a transmission, not shown, is transferred from ring gear 48 through housing 44 to pinion shaft 56 which, in turn, drive a pair of bevel pinions 60. As will be apparent to those of skill in the art, pinion shaft 56 can ride in suitable bores in housing 44, as illustrated below, or pinion shaft 56 can ride in suitable bushings (not shown) which can be provided in bores in housing 44. Bevel pinions 60 engage with complementary bevel gears 64 which are connected to a right and left axle shaft (not shown) respectively which engage, via splines, with a central bore in each respective bevel gear 64. A washer 66 having a complementary shape to the inner surface of housing 44 and to the spherical surfaces of bevel pinions 60 and bevel gears 64 and having a central bore through which pinion shaft 56 passes, is installed between the inner surface of housing 44 and pinions 60 and gears 64 as shown.

[0017] A housing-cover 68, which is also preferably die-formed as described below, is attached to housing 44 to close the differential 40 and to provide support for a bearing to carry differential 40 in its

casing (not shown). Housing-cover 68 can be attached to housing 44 in any suitable manner as will occur to those of skill in the art, including welding and/or screws.

[0018] Figures 3a, 3b, 3c and 3d shows a presently preferred method of die-forming housing 44. As shown in Figure 3a, a die blank 100 is provided. Blank 100 is a suitable low carbon steel, as will be understood by those of skill in the art, and is disc shaped. Through die-forming operations with one or more pairs of punches and dies, blank 100 is formed to the generally cup shaped body 104 shown in Figure 3b. Body 104 now includes a flange 108, a generally spherical inner portion 112 and a generally conical support portion 116. A small central bore 120 is also formed in the center of spherical portion 112.

[0019] Next, as shown in Figure 3c, bore 120 is formed into hub area 124 through one or more die-forming operations and body 104 can be machined as indicated by dashed lines 128 and 130, if necessary, to achieve desired tolerances and clearances. For example, hub area 124 can be machined to form a journal and shoulder to receive a bearing.

[0020] Finally, as shown in Figure 3d and Figure 4, body 104 is machined to include attachment points 132 (if necessary) for ring gear 48, to form the journals and bores 136 for pinions 56, to form oil lubrication holes 140 and to form surface 144 to which housing cover 68 can be attached, to obtain housing 44.

[0021] As will be apparent to those of skill in the art, further processing of differential housing 44 and/or housing cover 68 can be performed if required. For example, heat treating of housing 44 and/or cover 68 can be performed if desired to further strengthen these components. Also, welds, gussets and other strengthening structures can be added if desired.

[0022] The die-forming of differential housing 44 and housing cover 68 provides several advantages of the prior art. The above-mentioned disadvantages with respect to the size and weight of cast iron housings are avoided. Further, die-forming is a relatively fast process, compared to cold flow-forming and/or cold spin-forming and is less expensive to employ. Further, the die forming process better supports flexible manufacturing techniques. A manufacturing line established to manufacture the housing and housing cover for one differential can easily and quickly have its pairs of dies and punches changed to manufacture other differentials.

[0023] Figures 5a and 5b show some of the steps in a presently preferred method of manufacturing housing cover 68. In a manner similar to that discussed above for forming housing 44, a disc shaped blank (not shown) of low carbon steel is die-formed, by die-forming operations with one or more die and punch pairs to obtain the cup shaped body 160 shown in Figure 5a. Body 160 includes a spherical inner portion 164 and a hub portion 168. Depending upon the tolerances and clearances required, and

the accuracy of the die-forming process, inner portion 164 can be machined, as indicated by dashed line 172 to the requires final shape and hub portion can be machined to provide a journal and shoulder for a bearing, as indicated by dashed line 176. To provide for connection to housing 44, edge 180 can be machined to achieve the required tolerance as indicated by dashed line 184.

[0024] Completing the process; as shown in Figure 5b and Figure 6, two or more oil lubrication holes 188 can be machined into body 160 and journals and bores 192 for pinion shaft 56 can be machined as well to obtain housing cover 68.

[0025] Figures 7a through 7e show the steps to assemble differential 40. As illustrated in Figure 7a, a subassembly 200 is first assembled from bevel gears 64, meshed bevel pinions 60, washer 66 and pinion shaft 56 which inserted into bevel pinions 60. Subassembly 200 is installed in housing 44 with the ends of pinion shaft 56 being received in journals and bores 136 in housing 44. As shown in Figure 7b, housing cover 68 is then fitted to housing 44 bringing edge 180 of housing cover 68 into contact with surface 144 while ensuring that journals and bores 192 correctly engage pinion shaft 56 as shown in Figure 7c. Housing cover 68 is then permanently welded, or otherwise connected, to housing 44 at 196. Next differential ring gear 48 is connected to housing 44 be rivets 52, or another suitable connection means, as shown in Figure 7d. Finally, assembly is completed by adding bushings 200 and bearings 204, which can be tapered roller bearings or radial ball bearings or any other suitable bearings, to the hubs of housing 44 and housing cover 68 as illustrated in Figure 7e. Completed differential 40 can then be installed in a casing, as required.

[0026] As will be apparent to those of skill in the art, depending upon the torque which differential 40 is intended to carry, differential 40 can include three or four pinion shafts 56 and associated pinions 60 to increase the contact area between pinions 60 and bevel gears 64 to better carry the torque.

[0027] Figure 8 shows another configuration of differential 40, wherein bearings 204 include a long inner race 208, thus eliminating the need for bushings 200.

[0028] Figure 9 shows another configuration of differential 40, wherein ring gear 48 is connected to housing 44 by welding, rather than by rivets or screws. As illustrated, housing is 44 is slightly modified in shape, removing the laterally extending flange 46 and instead providing cylindrical flange 212 to which ring gear 48 is welded via a bead 216 of weld. Figure 9 also illustrated the weld bead 196 which can be used to join housing 44 to housing cover 68.

[0029] The above-described embodiments of the invention are intended to be examples of the present invention and alterations and modifications may be effected thereto, by those of skill in the art, without departing from the scope of the invention which is defined solely by the claims appended hereto.

We claim:

1. A differential comprising:

a differential housing die-formed from a steel blank including a generally spherical volume within the housing;

a subassembly installed in the generally spherical volume of the differential housing and comprising a pinion shaft, a pair of bevel pinions on the pinion shaft and a complementary pair of bevel gears;

a housing closure die-formed from steel blank and mounted to the differential enclosure to enclose said subassembly; and

a ring gear mounted to said differential housing to receive transmitted torque from a prime mover, the differential housing including a hub portion to accept an axle to engage one of the bevel gears and the housing closure also having a hub portion to accept a second axle to engage the other of the bevel gears.

2. A method of manufacturing a differential comprising the steps of:

(i) forming a differential housing from a steel blank through a series of forming operations with die and punch pairs, the differential housing including a generally spherical volume and a hub portion with a through aperture;

(ii) forming a housing closure from a steel blank through a series of forming operations with die and punch pairs, the housing closure including a hub portion with a through aperture;

(iii) assembling a sub-assembly of a pinion shaft, at least two bevel pinions and at least two complementary bevel gears;

(iv) inserting the sub-assembly into the generally spherical volume in the differential housing such that the through aperture aligns with an inner splined aperture on one bevel gear to receive a splined portion of an axle;

(v) mounting the housing closure to the differential housing to enclose the sub-assembly such that the through aperture aligns with an inner splined aperture on the other bevel gear to receive a splined portion of an axle; and

(vi) mounting a ring gear to the differential housing.

ABSTRACT

[0030] A novel differential and method of a making the differential is presented wherein the differential housing and housing closure are manufactured by die-forming. The obtained differential is both light and strong and reasonably inexpensive to manufacture.

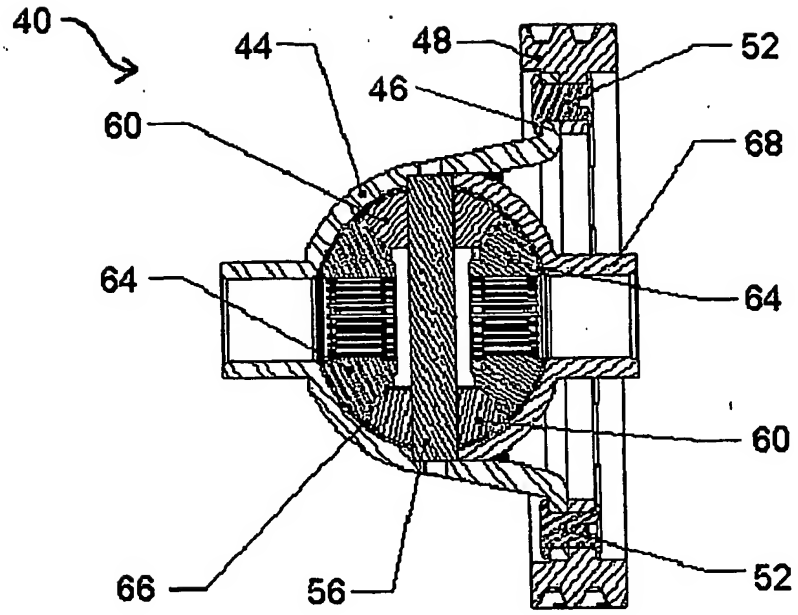

Fig. 1

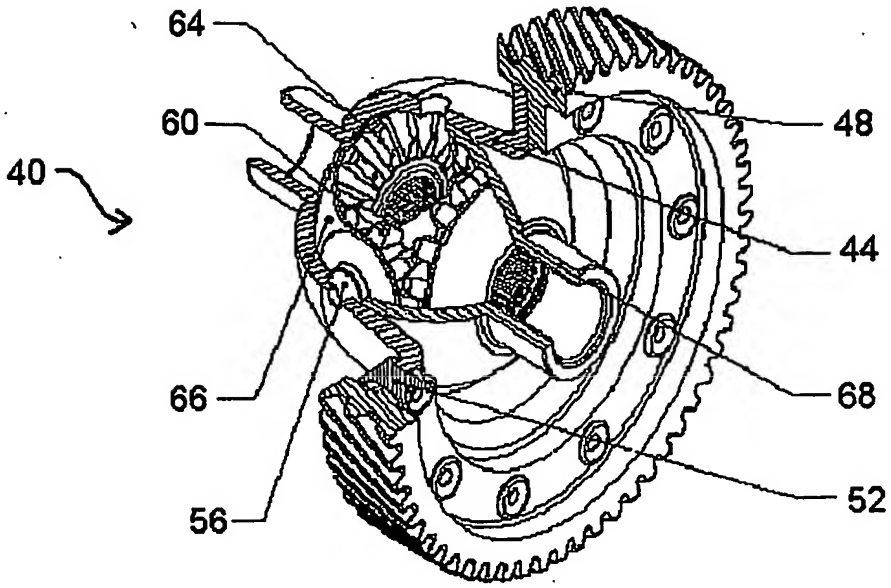

Fig. 2

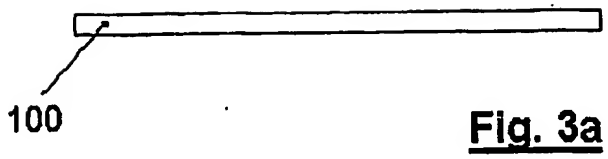

Fig. 3a

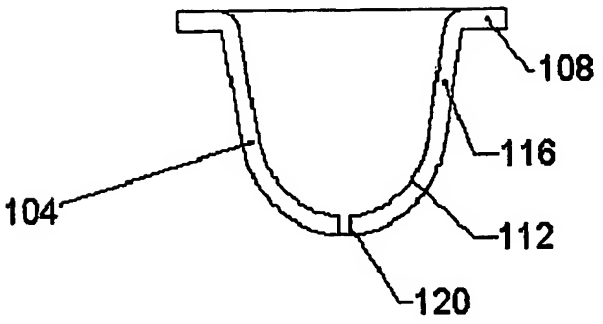

Fig. 3b

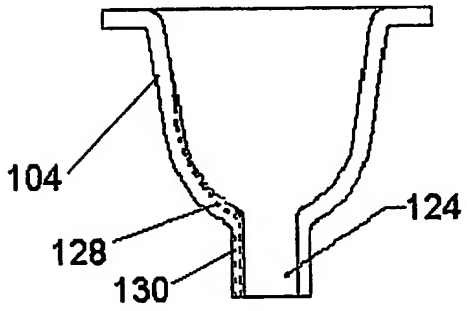

Fig. 3c

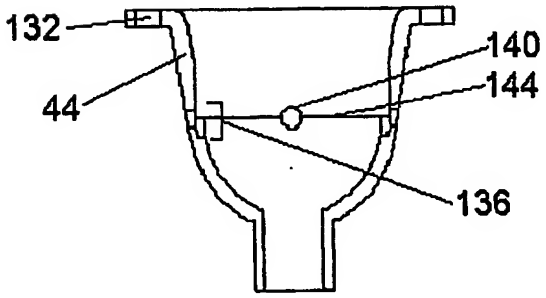

Fig. 3d

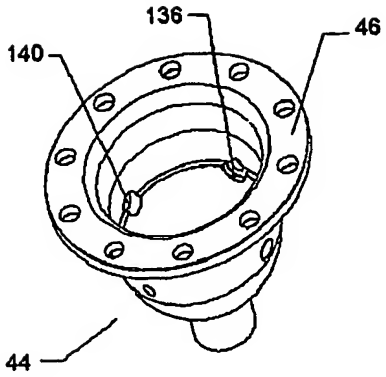

Fig. 4

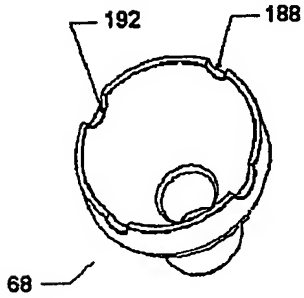

Fig. 6

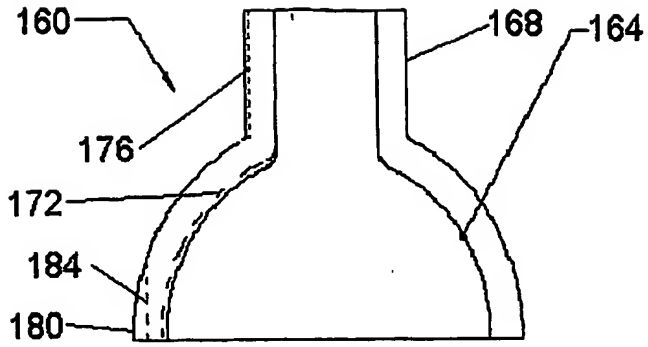

Fig. 5a

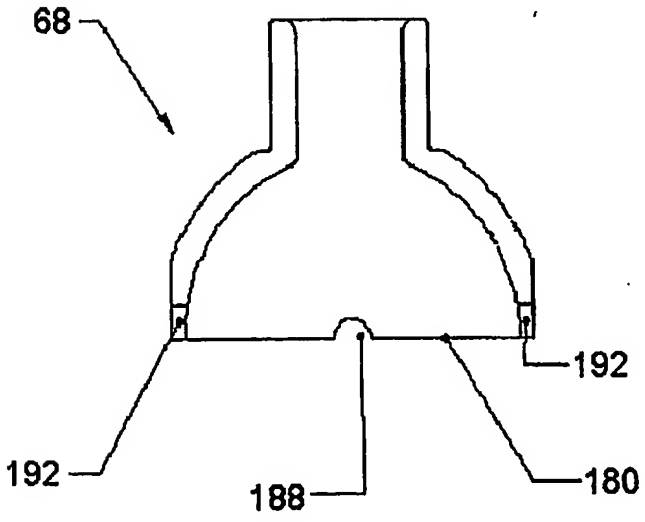

Fig. 5b

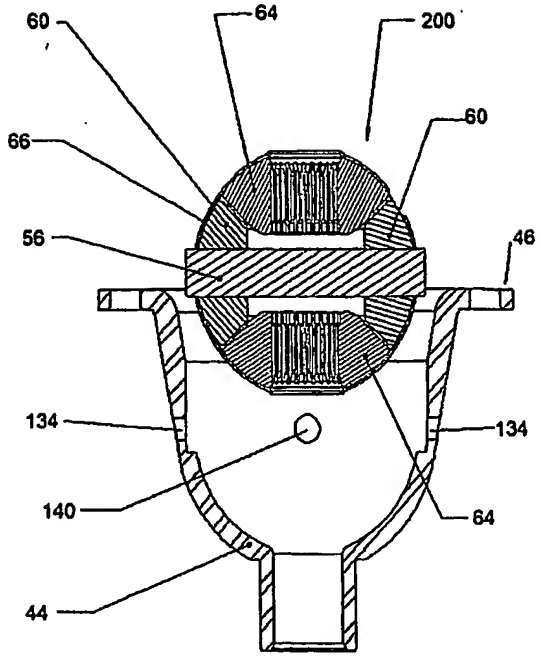

Fig. 7a

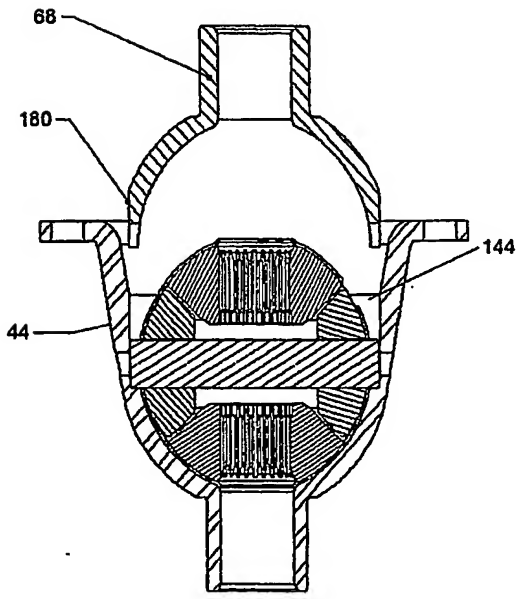

Fig.7b

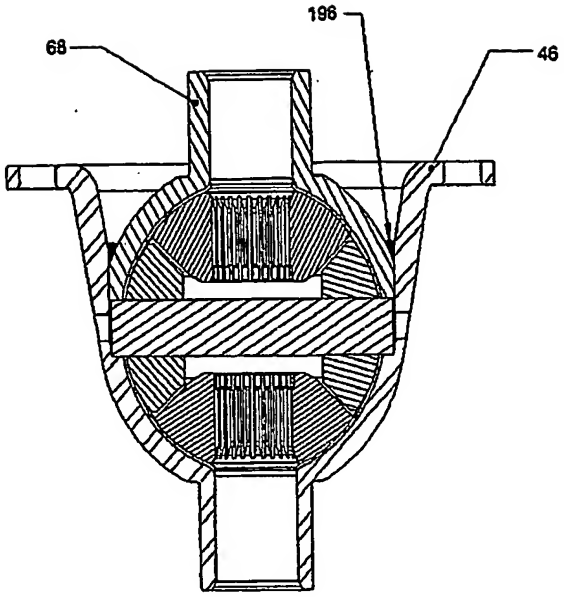

Fig.7c

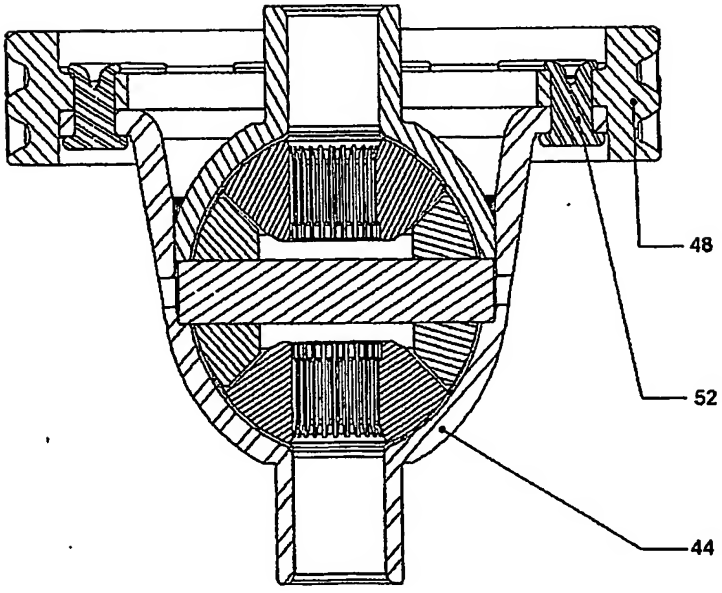

Fig. 7d

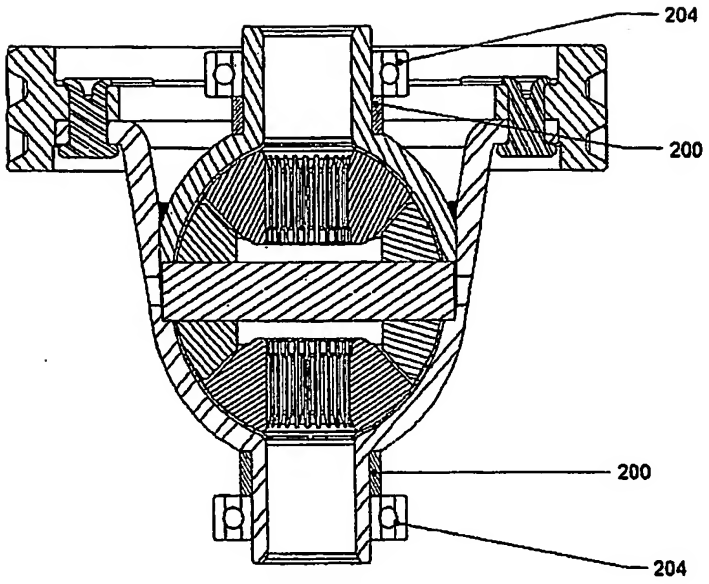

Fig. 7e

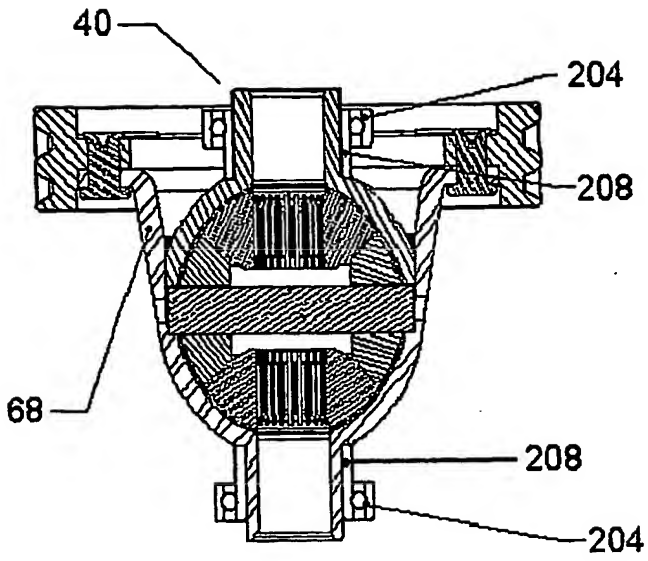

Fig. 8

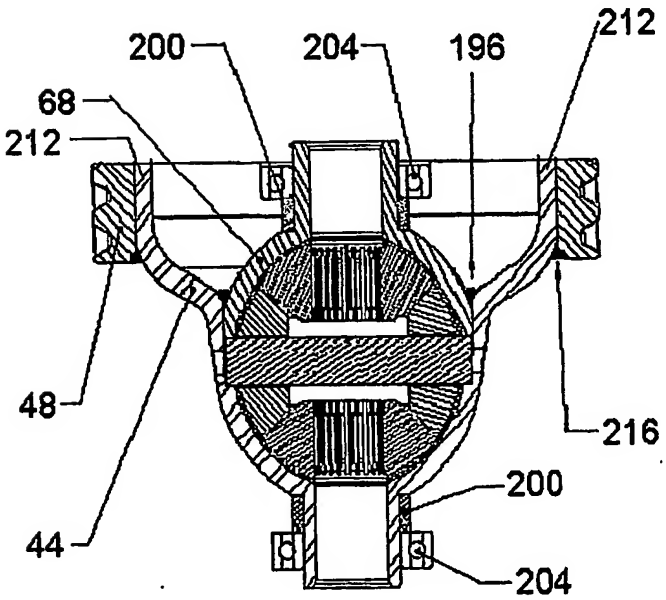

Fig. 9